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The Effect of Common Insecticides on Two Parasitoids (Hymenoptera: Eulophidae) of Liriomyza trifolii (Burgess) (Diptera: Agromyzidae) 【Research report】

非洲菊園內常用藥劑對非洲菊斑潛蠅 (Liriomyza trifolii (Burgess)) (雙翅目：潛蠅科) 兩種寄生蜂 (膜翅目：釉小蜂科) 之影響【研究報告】

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Abstract

In Taiwan Hemiptarsenus varicornis (Girault) and Neochrysocharis formosa (Westwood) are important native parasitoids of Liriomyza trifolii (Burgess). Seedlings of field bean with either parasitoid or L. trifolii were used to study the effects of six insecticides (cartap, thiocyclam, triazophos, pyrazophos, abamectin, and cyromazine) on the different life stages of parasitoids by dipping method in the laboratory. The results showed that the susceptibility to insecticides were similar for both parasitoids. The most toxic insecticides were cartap, thiocyclam and triazophos, followed by pyrazophos, abamectin and cyromazine. The adult stage was more vulnerable to the tested insecticides than the immature stages. N. formosa was generally more tolerant to five of the insecticides tested than H. varicornis, but the susceptibility of both parasitoids to triazophos was similar. When comparing the use of only one of the parasitoids with the combination of both parasitoid and insecticide, the percentage of hosts killed by applying the parasitoid and the insecticide simultaneously increased 10.9 ~ 11.1 and 30.6 ~ 30.8% for H. varicornis and N. formosa, respectively. The results of this study suggest that cyromazine can conserve parasitoids and could be incorporated into L. trifolii control programs. Strategies for integrated management of disease, pests and mites on Gerbera jamesonii Bolues ex Hook. F. were also discussed.

摘要

異角釉小蜂 (Hemiptarsenus varicornis (Girault)) 與華釉小蜂 (Neochrysocharis formosa (Westwood)) 是非洲菊斑潛蠅 (Liriomyza trifolii (Burgess)) 本地種之重要寄生蜂。本文以浸漬帶有寄生蜂或僅帶有寄主豆葉之方法於室內測試六種藥劑 (培丹、硫賜安、三落松、白粉松、阿巴汀及賽滅淨) 對兩種寄生蜂未成熟期與成蟲期之毒害。結果得知寄生蜂間對藥劑種類具相似之感受性，其中對寄生蜂影響最毒之藥劑為培丹、硫賜安及三落松，其次者為白粉松，再次者為阿巴汀，至於賽滅淨則對寄生蜂毒害最低。藥劑對成蟲期之毒害大於未成熟期。除三落松對兩種寄生蜂之毒害程度相似外，其他五種藥劑對異角釉小蜂之毒害均大於華釉小蜂。藥劑與寄生蜂並用對斑潛蠅的致死率，比單獨用異角釉小蜂與華釉小蜂各增加 10.9 ~ 11.1 與 30.6 ~ 30.8%。賽滅淨與兩種寄生蜂間相容性較大，慎選賽滅淨防治非洲菊斑潛蠅，異角釉小蜂與華釉小蜂即可獲得較佳的保育。文中尚建議非洲菊園內病、蟲及蟎害之綜合防治策略。

Key words: Liriomyza trifolii, Hemiptarsenus varicornis, Neochrysocharis formosa, insecticides, stages

關鍵詞: 非洲菊斑潛蠅、異角釉小蜂、華釉小蜂、藥劑、蟲期。

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非洲菊園內常用藥劑對非洲菊斑潛蠅 (*Liriomyza trifolii* (Burgess)) (雙翅目：潛蠅科) 兩種寄生蜂 (膜翅目：釉小蜂科) 之影響

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摘 要

異角釉小蜂 (*Hemiptarsenus varicornis* (Girault)) 與華釉小蜂 (*Neochrysocharis formosa* (Westwood)) 是非洲菊斑潛蠅 (*Liriomyza trifolii* (Burgess)) 本地種之重要寄生蜂。本文以浸漬帶有寄生蜂或僅帶有寄主豆葉之方法於室內測試六種藥劑 (培丹、硫賜安、三落松、白粉松、阿巴汀及賽滅淨) 對兩種寄生蜂未成熟期與成蟲期之毒害。結果得知寄生蜂間對藥劑種類具相似之感受性，其中對寄生蜂影響最毒之藥劑為培丹、硫賜安及三落松，其次者為白粉松，再次者為阿巴汀，至於賽滅淨則對寄生蜂毒害最低。藥劑對成蟲期之毒害大於未成熟期。除三落松對兩種寄生蜂之毒害程度相似外，其他五種藥劑對異角釉小蜂之毒害均大於華釉小蜂。藥劑與寄生蜂並用對斑潛蠅的致死率，比單獨用異角釉小蜂與華釉小蜂各增加 10.9～11.1 與 30.6～30.8%。賽滅淨與兩種寄生蜂間相容性較大，慎選賽滅淨防治非洲菊斑潛蠅，異角釉小蜂與華釉小蜂即可獲得較佳的保育。文中尚建議非洲菊園內病、蟲及蟎害之綜合防治策略。

關鍵詞：非洲菊斑潛蠅、異角釉小蜂、華釉小蜂、藥劑、蟲期。

前 言

非洲菊斑潛蠅 (*Liriomyza trifolii* (Burgess)) 爲世界性重要之觀賞園藝與蔬菜作物害蟲 (Lindquist, 1983; Minkenberg and van Lenteren, 1986)。由於斑潛蠅對化學藥劑易生抗藥性 (Parrella *et al*., 1984; Hara, 1986; Broadbent and Pree, 1989)、廣效性藥劑對其寄生蜂之毒害影響 (Spencer, 1973)、防治斑潛蠅藥劑之有效壽命 (effective life) 不及 2 年 (Leibee, 1981) 或僅 2 年 (Poe and Strandberg, 1979) 等因素，致使斑潛蠅防治不易。針對此點，除多位學者建議減少施藥頻率與劑量 (Mason *et al*., 1989) 及採用輪用

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藥劑 (Trumble, 1985a; FFVA, 1991; Ferguson, 2004) 以減少斑潛蠅抗藥性之發展外，在保育本地種寄生蜂方面，除篩選對寄生蜂低毒之選擇性藥劑外 (Saito *et al*., 1996)，Poe *et al*. (1978)、Waddill (1978)、Trumble and Toscano (1983) 及 Trumble (1985b) 等亦建議當使用一種藥劑防治斑潛蠅前，應先測試該藥劑對其寄生蜂種類之影響，並據此作爲使用該藥劑之參考。在臺灣，花卉上除已有推薦防治非洲菊斑潛蠅之有效藥劑，如培丹 (cartap)、硫賜安 (thiocyclam)、三落松 (triazophos)、白粉松 (pyrazophos)、阿巴汀 (abamectin) 及賽滅淨 (cyromazine) (Anonymous, 2004; Chien *et al*. 2007) 外，該蠅之本地種寄生蜂不僅種類多達 9 種 (Lin and Wang, 1992; Hansson and LaSalle, 1996; Chien and Ku, 1998)，且其中之異角釉小蜂 (*Hemiptarsenus varicornis* (Girault)) 與華釉小蜂 (*Neochrysocharis formosa* (Westwood)) 不但爲優勢蜂種 (Chien and Ku, 1998)，且爲有效寄生蜂 (Chien and Ku, 2001a, b, c, 2002; Chien *et al*. 2004; Chien *et al*., 2005a, b, c)。同時非洲菊栽培因植株每二至三年更新一次棲所之穩定性與僅收穫花的部分供做切花用之特性，致使非洲菊園內非洲菊斑潛蠅十分適合生物防治。因而在非洲菊園內病、蟲及蟎害防治中，有關藥劑對非洲菊斑潛蠅寄生蜂之影響，即成爲一重要研究項目。本研究以行政院農業委員會審定植物保護手冊中推薦防治非洲菊斑潛蠅之藥劑—培丹、硫賜安、三落松、阿巴汀及賽滅淨，與臺中大坑地區花農自行防治白粉病之藥劑—白粉松爲供試藥劑，於室內偵測此六種藥劑在現行推薦濃度下對非洲菊斑潛蠅兩種重要寄生蜂—異角釉小蜂與華釉小蜂之影響，期能將結果提供非洲菊園內病、蟲及蟎害綜合防治之參考。

材料與方法

一、寄主植物之栽培

每週定期浸泡菜豆 (*Phaseolus vulgaris* var. *communis* Aeschers) 種子 300 粒。在 25°C 下經 7 小時種子吸水飽滿後，將其瀝淨，置於塑膠盤內進行催芽，期間並蓋上另一塑膠盤以保持濕度，待 14 小時種子發根後，即移種在溫室置有 3 號蛭石之穴盤 (長 36.5 cm，寬 28 cm，高 4.5 cm；30 穴) 內。每天澆水，經 10～13 天，菜豆苗發育至株高 15～20 cm，真葉 (primary leaf) 葉寬達 7～9 cm 時，即可供室內非洲菊斑潛蠅產卵用。

二、寄主與寄生蜂之採集

在臺中大坑非洲菊園內採集被非洲菊斑潛蠅幼蟲爲害之葉片，攜回室內並將被害葉放入塑膠盤內，待幼蟲化蛹，然後將蛹與被害葉置入內徑 21 cm 之塑膠圓盤內，並罩以一端有紗網覆蓋之壓克力筒 (直徑 20 cm、高 25 cm)。待成蠅與其兩種寄生蜂—異角釉小蜂與華釉小蜂羽化，供做飼育之蟲源。

三、寄主與寄生蜂之繁殖

參照 Chien and Ku (1996, 2001a) 飼育非洲菊斑潛蠅與其寄生蜂之方法，在室內 25°C 定溫下，以株高 20 cm、真葉寬 7～9 cm 之菜豆苗供非洲菊斑潛蠅產卵，待幼蟲發育至第三齡時，再以帶有該幼蟲潛食之罐插菜豆苗供異角釉小蜂與華釉小蜂產卵及幼蟲與蛹之發育。

四、供試藥劑與帶蟲豆苗浸漬之處理方法

供試藥劑　六種供試藥劑與濃度分別選自植物保護手冊內推薦防治非洲菊斑潛蠅之五種殺蟲劑—培丹、硫賜安、三落松、阿巴汀

表一　供試藥劑種類、濃度、化學類別、使用型態及出品公司
Table 1. Chemicals and concentrations used for this study and their characters

Common names and formulation	Dilution factor	Chemical class	Use type	Manufacturer
Cartap 50% S.P.	1000	nereistoxin	insecticide	Harvest Chemical Co., Ltd.
Thiocyclam 50% W.P.	1000	nereistoxin	insecticide	Worldwide Agrochemical Co., Ltd.
Triazophos 40% E.C.	1000	organophosphate	insecticide, acaricide, nematicide	Gharda Chemicals Ltd., India
Pyrazophos 30% E.C.	2000	organophosphate	insecticide, fungicide	BASF Taiwan Ltd.
Abamectin 2% E.C.	2000	avermectins	insecticide, acaricide, nematicide	Syngenta Taiwan Ltd.
Cyromazine 75% W.P.	5000	triazine	insecticide (insect growth regulator)	Syngenta Taiwan Ltd.

及賽滅淨 (Anonymous, 2004)，及加上花農慣行於非洲菊園內防治白粉病之一種藥劑—白粉松。藥劑種類、濃度、化學類別、使用形態及出品公司等詳見表一。

帶蟲豆苗之預備

1. 帶有寄主豆苗之預備　在 25°C 定溫下，將 80 隻非洲菊斑潛蠅雌蟲接入內置有 30 株菜豆苗之繁殖網箱 (長 75 cm，寬 55 cm，高 50 cm)，經產卵 7 小時 (上午 9 點至下午 4 點) 後，將眞葉內帶有卵之菜豆苗移出，並放置於溫度 25°C、相對濕度 65～85% RH 及光周期 14:10 (L:D) (上午 5 點至下午 7 點間照光) 下之室內繼續飼養，待寄主發育至第三齡幼蟲時 (產卵後第六日)，一方面供應後述寄生蜂之產卵，另方面則供應帶有寄主豆苗浸藥與不浸藥時之材料。所有供試之帶有寄主豆苗祇留有 2 片眞葉，複葉 (trifoliate leaf) 均摘除。

2. 帶有寄生蜂豆苗之預備　在與上項相同溫度、濕度、光周期及產卵時間下，先將 4 至 5 株帶有共約 300 隻寄主之豆苗合插於一個罐蓋上有圓孔 (直徑 1.5 cm) 之盛水塑膠罐內 (直徑 4 cm、高 5 cm)，置入內徑 21 cm 之塑膠圓盤，並罩以上述相同大小之壓克力筒，各接入 15～20 隻已交尾且有產卵經驗之異角釉小蜂或華釉小蜂雌蜂，經產卵 7 小時後，將眞葉內帶有蜂卵之菜豆苗移出，置於相同環境下繼續飼養，以供後述藥效試驗，包括帶有卵 (產卵後第二日)、或帶有第四齡老熟幼蟲 (產卵後第五日)、或帶有蛹 (化蛹當日) 之豆苗。所有供試之帶有寄生蜂豆苗祇留有 2 片眞葉，複葉均摘除。

帶蟲豆苗浸漬藥劑之處理

1. 帶有寄生蜂豆苗之浸藥　各將眞葉內寄主體上已有異角釉小蜂卵或寄主體內已有華釉小蜂卵 20～50 粒、或眞葉內各有 20～40 隻寄生蜂第四齡老熟幼蟲，或眞葉內各有 20～40 個寄生蜂蛹之單株菜豆苗，齊根剪下分別倒插浸漬在盛有稀釋藥液之 2000 ml 塑膠杯內 1 分鐘，之後再將其分別插入試管架上已有水之試管內 (直徑 1.5 cm、高 7 cm)，自然風乾 30 分鐘後，距豆苗剪口 5 cm 處以

海綿片束紮，並直插入上述相同大小之盛水塑膠罐底部。然後每罐插豆苗再分別置入前述之塑膠圓盤，並罩以壓克力筒，供各項試驗用。

2. 帶有寄主豆苗之浸藥　在 25°C 下，將眞葉內各帶有 40～50 或 60～80 隻第三齡中、或三齡初寄主幼蟲之單株菜豆苗，齊根剪下照上述浸漬法浸藥後供試。

3. 對照組之浸水處理　其方法與過程與浸藥處理相同，僅豆苗浸漬藥劑時，對照組係以水替代之。

五、卵期施藥對各未成熟期之影響

於 25°C 定溫下，帶有寄生蜂卵之豆苗浸藥處理後第五天，剪下葉片，置入直徑 9 cm、高 1.5 cm 之塑膠培養皿內，記錄各處理組卵期之死亡數及其後幼蟲與蛹期之發育情形。其中異角釉小蜂未孵化卵數之計數，係待該蜂已發育至老熟幼蟲後，揭開豆葉，檢視寄主體上或體旁未孵化之卵數；而華釉小蜂未孵化卵數之計數，則係待該蜂已發育至老熟幼蟲後，解剖葉片內所有已死但外形仍飽滿之寄主，檢視其體內未孵化之卵數與死亡幼蟲數。卵存活百分率公式爲〔幼蟲數 ÷(幼蟲數 + 未孵化卵數) × 100%〕。另設僅浸水處理之對照組。每處理各做 4～5 重複。

六、第四齡老熟幼蟲期施藥對幼蟲與蛹之影響

在 25°C 定溫下，帶有寄生蜂第四齡老熟幼蟲之豆苗浸藥處理後第二天，剪下葉片，置入前述相同大小之塑膠培養皿內，記錄各處理組幼蟲期之死亡數及蛹期之發育情形。另設僅浸水處理之對照組。每處理各做 3～5 重複。

七、蛹期施藥對蛹之影響

在 25°C 定溫下，帶有寄生蜂蛹之豆苗浸藥處理後第二天，剪下葉片，置入前述相同大小之塑膠培養皿內，記錄各處理組蛹之發育情形。另設僅浸水處理之對照組。每處理各做 4～5 重複。

八、藥劑對成蟲之影響

帶有寄主豆苗浸藥後再接蜂 24 小時　在 25°C 定溫下，早上 9 點將 2 日齡已交尾產卵成蜂 20 對或 20 隻雌蜂各置入直徑 20 cm、高 25 cm 壓克力筒內，除分別供應浸藥後 30 分鐘之帶蟲 (寄主第三齡中幼蟲 300 隻) 豆苗或浸藥後 1 日之帶蟲 (寄主第三齡初幼蟲 300 隻) 豆苗，供其產卵與取食，另以細毛筆將純蜂蜜塗於壓克力筒內壁供成蜂食用。24 小時後，成蜂移出，記錄雌、雄蜂之存活數，豆苗仍留在原壓克力筒內，依 Chien and Ku (2001a) 之方法，距雌蜂與藥劑接觸後之次日、5～6 日及 12～14 日，分別記錄原浸藥豆葉上寄主幼蟲之死亡數、子代寄生蜂之蛹數與成蟲數等。前者供試藥劑共六種，後者供試藥劑僅白粉松、阿巴汀及賽滅淨三種。另設僅浸水處理之對照組。每處理各做 3～5 重複。

接蜂 24 小時後存活個體之後續觀察　爲觀測阿巴汀與賽滅淨處理成蜂 24 小時後對該蜂壽命、生殖力及其致死寄主蟲數之影響，乃在上述帶有寄主豆苗浸藥後 30 分鐘，再接蜂 24 小時後，自存活成蜂中隨機選取 1 對成蜂，置入另一直徑 20 cm、高 25 cm 壓克力筒內，每日供應純蜂蜜與未經浸藥處理帶有 40～50 隻第三齡寄主幼蟲之單株罐插豆苗，直至雌蜂死亡爲止。然後依 Chien and Ku (2001a) 之方法，計數該蜂之壽命、生殖力、子代雌性比、寄生致死寄主數、取食致死寄主數及致死寄主總數。對照組之成蜂則是選自藥劑試驗中對照組之存活成蜂。每處理各做 7～17 重複。

表二　異角釉小蜂與華釉小蜂卵經不同藥劑處理後未成熟期之存活率[1)]

Table 2. Survival rate of immature stages of *Hemiptarsenus varicornis* and *Neochrysocharis formosa* after their eggs were treated with various insecticides[1)]

Insecticides	*n*	Percent survival			
		Egg	Larva	Pupa	Egg-pupa
			H. varicornis		
Cartap	5	25.0 ± 4.3c[2)]	16.2 ± 9.1b	100.0a	3.9 ± 1.9cd
Thiocyclam	4	43.9 ± 8.6b	8.2 ± 3.2bc	33.3 ± 33.3bc	0.9 ± 0.9d
Triazophos	4	53.6 ± 6.3b	1.1 ± 1.1c	25.0 ± 25.0c	0.7 ± 0.7d
Pyrazophos	5	93.7 ± 0.8a	9.2 ± 3.6bc	83.4 ± 9.6abc	6.4 ± 2.1c
Abamectin	5	96.9 ± 1.4a	93.1 ± 1.5a	94.1 ± 1.8a	87.5 ± 2.0ab
Cyromazine	4	97.4 ± 1.7a	94.6 ± 2.4a	88.7 ± 3.2ab	81.5 ± 2.3b
CK	4	96.0 ± 2.6a	100.0a	97.0 ± 2.0a	93.0 ± 1.7a
			N. formosa		
Cartap	4	98.5 ± 0.5ab	81.9 ± 7.2b	23.9 ± 2.2d	19.3 ± 2.6c
Thiocyclam	4	97.8 ± 1.4ab	87.3 ± 4.3b	60.9 ± 9.8c	52.5 ± 9.0b
Triazophos	4	100.0ab	0d	-	0d
Pyrazophos	5	96.1 ± 1.8b	68.7 ± 1.8c	89.8 ± 3.3b	59.7 ± 4.6b
Abamectin	5	97.3 ± 1.9ab	99.2 ± 0.5a	97.4 ± 1.2a	93.2 ± 2.7a
Cyromazine	5	100.0a	99.1 ± 0.6a	93.6 ± 2.1ab	92.7 ± 0.4a
CK	4	98.2 ± 1.2ab	99.5 ± 0.6a	98.1 ± 1.2a	95.8 ± 1.6a

1) Seedling of field bean inoculated with 20-50 eggs were dipped in insecticide solution for 1 min. Untreated controls were dipped in distilled water instead. Each treatment contained one seedling in an individual acrylic cylinder (20 cm diameter × 25 cm high) and they were placed under 25°C, 14L:10D, and 65-85% R.H. 30 min after treatment.

2) Means ($\bar{x}$ ± SEM) within each column followed by the same letter are not significantly different ($p < 0.05$, LSD). Data were transformed to arcsin$\sqrt{x}$ prior to ANOVA.

九、統計分析

各項試驗資料利用 SPSS (Statistical Products and Services Solutions) 軟體先進行變方分析，再以最小顯著差 (LSD) 法或 *t* 值測試法檢測，並採 $p < 0.05$ 之顯著水準比較處理間之差異性。若遇百分率時，資料先進行角度轉換 (arcsine transformation)，再進行分析。

結　　果

一、卵期施藥對各未成熟期之影響

異角釉小蜂　六種供試藥劑中僅培丹、硫賜安及三落松等三種藥劑對卵具顯著毒害，致使其孵化率各降為 25.0、43.9 及 53.6% (表二)。持續觀察孵化幼蟲在原浸藥處理寄主體上之發育，則發現培丹、硫賜安、三落松及白粉松等四種藥劑對寄生蜂具累計毒害，幼蟲期與卵至蛹期之存活率各顯著降低為 1.1～16.2 與 0.7～6.4% (表二)。賽滅淨對卵或其後孵化之幼蟲與蛹雖無顯著單一毒害，但對寄生蜂之累計毒害，仍使卵至蛹期之存活率 (81.5%) 與對照組 (93.0%) 間呈顯著差異 (表二)。至於阿巴汀對寄生蜂則無顯著毒害，卵發育至蛹期之存活率高達 87.5% (表二)。

華釉小蜂　六種供試藥劑對卵均無顯著毒害，各處理組卵之孵化率高達 96.1～100% (表二)。持續觀察孵化幼蟲在原浸藥處理寄主

表三　異角釉小蜂與華釉小蜂老熟幼蟲經不同藥劑處理後未成熟期之存活率[1)]

Table 3. Survival rate of immature stages of *Hemiptarsenus varicornis* and *Neochrysocharis formosa* after their mature larvae were treated with various insecticides[1)]

Insecticides	n	Percent survival		
		Larva	Pupa	Larva-pupa
		H. varicornis		
Cartap	4	61.9 ± 2.7e[2)]	38.0 ± 5.3d	23.7 ± 3.9d
Thiocyclam	5	86.8 ± 2.0c	7.6 ± 4.0e	6.8 ± 3.6e
Triazophos	5	93.1 ± 0.8b	89.5 ± 2.4b	83.3 ± 2.4b
Pyrazophos	5	77.8 ± 2.2d	60.4 ± 2.1c	40.7 ± 2.0c
Abamectin	5	87.3 ± 1.2c	94.5 ± 1.7b	82.4 ± 1.6b
Cyromazine	4	98.2 ± 1.0a	100.0a	98.2 ± 1.0a
CK	4	98.4 ± 1.0a	96.3 ± 1.5ab	94.7 ± 2.1a
		N. formosa		
Cartap	5	95.6 ± 0.8b	22.1 ± 5.3d	21.0 ± 4.9e
Thiocyclam	5	99.0 ± 0.6a	41.2 ± 5.1c	40.7 ± 4.8d
Triazophos	3	93.8 ± 1.9b	83.9 ± 4.9b	79.7 ± 3.9bc
Pyrazophos	5	89.3 ± 2.7c	76.4 ± 1.8b	68.2 ± 2.7c
Abamectin	5	91.1 ± 1.1bc	93.9 ± 2.0a	85.4 ± 0.9b
Cyromazine	4	98.4 ± 0.5ab	95.8 ± 1.6a	94.3 ± 1.8a
CK	4	98.6 ± 0.8a	97.6 ± 1.6a	96.3 ± 1.1a

1) Seedling of field bean inoculated with 20-40 larvae was dipped in insecticide solution for 1 min. Untreated control was dipped in distilled water instead. Each treatment contained one seedling in an individual acrylic cylinder (20 cm diameter × 25 cm high) and they were placed under 25°C, 14L:10D, and 65-85% R.H. 30 min after treatment.

2) Means ($\bar{x}$ ± SEM) within each column followed by the same letter are not significantly different (p < 0.05, LSD). Data were transformed to arcsin$\sqrt{x}$ prior to ANOVA.

體內之發育，與老熟幼蟲鑽出寄主體外化蛹情形，發現三落松、白粉松、培丹與硫賜安等各顯著降低幼蟲之存活率爲 0、68.7、81.9～87.3%，培丹、硫賜安及白粉松等亦各顯著降低蛹之存活率爲 23.9、60.9 及 89.8% (表二)。各藥劑對卵發育至蛹期之毒害以三落松最高，其次爲培丹，再次爲硫賜安與白粉松，其存活率各降爲 0、19.3 及 52.5～59.7%。至於阿巴汀與賽滅淨對寄生蜂則無顯著毒害，卵發育至蛹期之存活率高達 92.7～93.2% (表二)。

二、第四齡老熟幼蟲期施藥對幼蟲與蛹之影響

異角釉小蜂　六種供試藥劑中除賽滅淨外，均對老熟幼蟲具顯著不同程度之毒害，同時亦顯著影響其後幼蟲至蛹之存活率 (表三)。如培丹、白粉松、硫賜安與阿巴汀、三落松致使幼蟲之存活率各降爲 61.9、77.8、86.8～87.3、93.1%；硫賜安、培丹、白粉松、三落松與阿巴汀不但致使蛹之存活率各降爲 7.6、38.0、60.4、89.5～94.5%，亦使幼蟲發育至蛹期之存活率各降爲 6.8、23.7、40.7、82.4～83.3%，與對照組 (94.7%) 間呈顯著差異。

華釉小蜂　六種供試藥劑中除硫賜安與賽滅淨外，均對老熟幼蟲具顯著不同強度之毒

表四　異角釉小蜂與華釉小蜂蛹經不同藥劑處理後之羽化率[1)]

Table 4. Emergence rate of *Hemiptarsenus varicornis* and *Neochrysocharis formosa* after their pupae treated with various insecticides[1)]

Insecticides	*H. varicornis*		*N. formosa*	
	n	$\bar{x}$ ± SEM	*n*	$\bar{x}$ ± SEM
Cartap	5	2.8 ± 1.7d[2)]	5	91.3 ± 1.7cd
Thiocyclam	6	3.3 ± 1.9d	5	83.7 ± 4.8d
Triazophos	4	76.4 ± 5.0b	6	86.1 ± 3.2cd
Pyrazophos	5	59.9 ± 2.4c	5	62.4 ± 1.9e
Abamectin	5	86.4 ± 0.2b	5	92.6 ± 3.3bc
Cyromazine	4	89.0 ± 2.0b	7	98.9 ± 1.1a
CK	4	97.3 ± 1.6a	4	98.0 ± 3.3ab

1) Seedling of field bean inoculated with 20-40 pupae was dipped in insecticide solution for 1 min. Untreated control was dipped in distilled water instead. Each treatment contained one seedling in an individual acrylic cylinder (20cm diameter × 25 cm high) and they were placed under 25°C, 14L:10D, and 65-85% R.H. 30 min after treatment.

2) Means within each column followed by the same letter are not significantly different (p < 0.05%, LSD). Data were transformed to arcsin$\sqrt{x}$ prior to ANOVA.

害，其中最強者為白粉松，其次者為培丹、三落松及阿巴汀，致使幼蟲之存活率各降為 89.3 與 91.1～95.6% (表三)。持續觀察其後蛹在原浸藥處理豆苗葉內之發育，則發現培丹、硫賜安、三落松與白粉松等不但致使蛹之存活率各降為 22.1、41.2、76.4～83.9%，亦使幼蟲發育至蛹期之存活率各降為 21.0、40.7、68.2～79.7%，與對照組 (96.3%) 間呈顯著差異 (表三)。阿巴汀雖不影響其後蛹之存活，但顯著降低幼蟲發育至蛹期之存活率為 85.4% (表三)。僅賽滅淨在老熟幼蟲期施用時，無論對幼蟲或蛹或幼蟲至蛹期均無顯著毒害 (表三)。

三、蛹期施藥對蛹之影響

異角釉小蜂　六種供試藥劑均對蛹具顯著不同強度之毒害，其中最強者為培丹與硫賜安，其次者為白粉松，再次者為三落松、阿巴汀及賽滅淨，致使該蜂之羽化率各降為 2.8～3.3、59.9 及 76.4～89.0%，與對照組 (97.3%) 間呈顯著差異 (表四)。

華釉小蜂　六種供試藥劑中除阿巴汀與賽滅淨外，其它藥劑均對蛹具顯著不同強度之毒害，最強者為白粉松，其次者為培丹、硫賜安及三落松，致使該蜂之羽化率各降為 62.4 與 83.7～91.3%，與對照組 (98.0%) 間呈顯著差異 (表四)。

四、藥劑對成蟲之影響

帶有寄主豆苗浸藥後 30 分鐘再接蜂 24 小時

異角釉小蜂　成蜂存活率方面，除賽滅淨外之五種供試藥劑均對成蜂之存活具顯著不同強度之毒害，依序為培丹與硫賜安、三落松、白粉松與阿巴汀，致使雌蜂之存活率各降為 0、10.0、47.4 與 48.0%，雄蜂之存活率各降為 0、21.2、43.7 與 59.4% (表五)。生殖力方面，前五種供試藥劑處理組之子代成蟲數 (0～13 隻) 不但較對照組 (77 隻) 顯著減少 83.1～100%，子代雌性比 (0.13) 亦較

表五　異角釉小蜂與華釉小蜂成蟲經不同藥劑處理 24 小時內之存活率、致死寄主率及子代數[1)]

Table 5. Survival rate, host killed rate and progeny of *Hemiptarsenus varicornis* and *Neochrysocharis formosa* during their adult stage treated with various insecticides for 24 hours[1)]

Treatment	Percent survival of adult			Percent host killed/ 20 females		Progeny/20 females			
	Female		Male			No. adults		Female proportion	
	A[2)]	B[2)]	A[2)]	A[2)]	B[2)]	A[2)]	B[2)]	A[2)]	B[2)]
				H. varicornis					
Cartap + wasp	0d[3)]	-	0e	99.8 ± 0.2a	-	0c	-	-	-
Thiocyclam + wasp	0d	-	0e	100a	-	0c	-	-	-
Triazophos + wasp	10.0 ± 7.1c	-	21.2 ± 6.3d	100a	-	0c	-	-	-
Pyrazophos + wasp	47.4 ± 5.0Ab	27.9 ± 7.6Ac	43.7 ± 3.6c	99.9 ± 0.1Aa	99.8 ± 0.2Aa	12 ± 4Ac	14 ± 3Ab	0.13 ± 0.06Bb	0.48 ± 0.04Ab
Abamectin + wasp	48.0 ± 2.8Bb	80.6 ± 4.2Ab	59.4 ± 4.8b	100Aa	99.8 ± 0.1Aa	13 ± 4Ac	22 ± 6Ab	0.13 ± 0.05Bb	0.38 ± 0.08Ab
Cyromazine + wasp	97.5 ± 1.4Aa	100Aa	97.5 ± 1.4a	99.8 ± 0.2Aa	100Aa	58 ± 7Bb	84 ± 5Aa	0.43 ± 0.02Ba	0.70 ± 0.07Aa
Water + wasp	100Aa	100Aa	100a	88.9 ± 2.9Ab	88.9 ± 2.9Ab	77 ± 8Aa	77 ± 8Aa	0.51 ± 0.03Aa	0.51 ± 0.03Ab
				N. formosa					
Cartap + wasp	0d	-	0d	100a	-	0d	-	-	-
Thiocyclam + wasp	0d	-	0d	99.8 ± 0.1a	-	3 ± 1d	-	0.64 ± 0.16a	-
Triazophos + wasp	0d	-	0d	99.9 ± 0.1a	-	0d	-	-	-
Pyrazophos + wasp	30.0 ± 2.9Ac	4.7 ± 3.1Bc	50.0 ± 2.9c	100Aa	99.8 ± 0.1Aa	45 ± 7Ac	43 ± 3Ab	0.53 ± 0.05Aa	0.68 ± 0.05Aa
Abamectin + wasp	93.3 ± 1.7Ab	71.5 ± 4.0Ab	93.3 ± 3.3b	99.9 ± 0.1Aa	100Aa	31 ± 4Ac	22 ± 4Ac	0.48 ± 0.04Ab	0.46 ± 0.04Ab
Cyromazine + wasp	99.0 ± 1.0Aa	100Aa	99.0 ± 1.0a	99.9 ± 0.1Aa	100Aa	101 ± 14Ab	45 ± 9Bb	0.63 ± 0.06Aa	0.69 ± 0.05Aa
Water + wasp	100Aa	100Aa	100a	69.2 ± 1.5Ab	69.2 ± 1.5Ab	164 ± 8Aa	164 ± 8Aa	0.70 ± 0.03Aa	0.70 ± 0.03Aa

1) Seedling of field bean infested by 60-80 third-instars of *L. trifolii* was dipped in insecticide solution for 1 min. Untreated control was dipped in distilled water instead. Each treatment had 3-5 replications, which contained 4-5 seedlings in an individual acrylic cylinder (20 cm diameter × 25 cm high). Twenty pairs of 2-day old wasp adults were released into the cylinder and placed under 25°C, 14L:10D, and 65-85% R.H.

2) A: After field bean leaf with *L. trifolii* larvae treated with insecticide for 30 min.
B: After field bean leaf with *L. trifolii* larvae treated with insecticide for 1 day.

3) Means ($\bar{x}$ ± SEM) within each row followed by the same uppercase letter are not significantly different ($p < 0.05$, t test). Means ($\bar{x}$ ± SEM) within each column followed by the same lowercase letter are not significantly different ($p < 0.05$, LSD). Percentage of survival data were transformed to arcsin$\sqrt{x}$ prior to ANOVA.

對照組 (0.51) 顯著減少 74.5%；而賽滅淨處理組僅子代成蟲數 (58 隻) 較對照組 (77 隻) 顯著減少 24.7% (表五)。致死寄主率方面，六種供試藥劑與雌蜂並用之各處理組之致死寄主率 (99.8～100%) 均較對照組 (88.9%) 顯著增加 10.9～11.1% (表五)。

華釉小蜂　成蜂存活率方面，除賽滅淨外之五種供試藥劑均對成蜂之存活具顯著不同強度之毒害，依序為培丹與硫賜安及三落松、白粉松、阿巴汀，致使雌蜂之存活率各降為 0、30.0、93.3%，雄蜂之存活率各降為 0、50.0、93.3% (表五)。生殖力方面，前五種供試藥劑與賽滅淨處理組之子代成蟲數各為 0～45 與 101 隻，較對照組 (164 隻) 各顯著減少 72.6～100 與 38.4%。子代雌性比方面，六種供試藥劑中，僅阿巴汀之子代雌性比 (0.48) 較對照組 (0.70) 減少 31.4%，其他各處理組與對照組間均無顯著差異 (表五)。致死寄主率方面，六種供試藥劑與雌蜂並用之各處理組之致死寄主率 (99.8～100%) 均較對照

組 (69.2%) 顯著增加 30.6～30.8% (表五)。

帶有寄主豆苗浸藥後 1 日再接蜂 24 小時

異角釉小蜂　白粉松與阿巴汀對雌蜂之存活率與子代成蟲數均具顯著不同強度之毒害，除致使雌蜂之存活率各降為 27.9 與 80.6%，亦使兩處理組子代成蟲數 (14～22 隻) 較對照組 (77 隻) 顯著減少 71.4～81.8% (表五)。賽滅淨對雌蜂之存活率或子代成蟲數不但無顯著影響，其子代雌性比 (0.70) 且較對照組 (0.51) 顯著增加 37.3% (表五)。致死寄主率方面，三種供試藥劑與雌蜂並用之致死寄主率 (99.8～100%) 均較對照組 (88.9%) 顯著增加 10.9～11.1% (表五)。

華釉小蜂　白粉松與阿巴汀對雌蜂之存活率與子代成蟲數具顯著不同強度之毒害，除致使雌蜂之存活率各降為 4.7 與 71.5%，亦使兩處理組子代成蟲數 (22～43 隻) 較對照組 (164 隻) 顯著減少 73.8～86.6% (表五)。賽滅淨對雌蜂之存活率雖無顯著影響，但其子代成蟲數 (45 隻) 卻較對照組 (164 隻) 顯著減少 72.6%。子代雌性比方面，供試藥劑中僅阿巴汀處理組 (0.46) 較對照組 (0.70) 顯著減少 34.3%，白粉松與賽滅淨則無顯著毒害 (表五)。致死寄主率方面，三種供試藥劑與雌蜂並用之各處理組之致死寄主率 (99.8～100%) 較對照組 (69.2%) 顯著增加 30.6～30.8% (表五)。

接蜂 24 小時後存活個體之後續觀察

異角釉小蜂　成蜂接觸藥劑 24 小時後，阿巴汀對雌蜂之影響顯著較賽滅淨強 (表六)。阿巴汀不論對雌蜂與雄蜂壽命 (8.8～9.9 日)、子代成蟲數 (16 隻) 及致死寄主總數 (53 隻) 等均有顯著影響，各較對照組降低 34.4～59.3、91.2 及 87.8% (表六)；而賽滅淨僅對子代成蟲數 (95 隻) 與致死寄主總數 (197 隻) 具顯著影響，各較對照組降低 47.5 與 54.8%。

華釉小蜂　成蜂接觸阿巴汀 24 小時後，其雌蜂壽命 (5.2 日)、子代成蟲數 (4 隻) 及致死寄主總數 (8 隻) 等均受顯著影響，各較對照組降低 76.7、97.9 及 97.7% (表六)；而賽滅淨對雌蜂之壽命 (21.4 日)、雄蜂之壽命 (7.0 日)、子代成蟲數 (215 隻) 及致死寄主總數 (357 隻) 等均無顯著影響 (表六)。

討論與結論

一、藥劑類型對斑潛蠅及其寄生蜂之影響

藥劑防治害蟲時，因藥劑化學類型 (chemical class) 與其作用機制之不同，對害蟲防治效果亦不同。Chien *et al*. (2007) 證實培丹、硫賜安、三落松、白粉松、阿巴汀及賽滅淨，不論其化學類型均可有效防治非洲菊斑潛蠅幼蟲，但若考慮成蟲之取食刻點與幼蟲食痕對觀賞植物之影響，對非洲菊斑潛蠅防治最佳之藥劑為培丹、硫賜安及阿巴汀，其次者為三落松與白粉松，再次者為賽滅淨。本試驗則得知兩種寄生蜂間對藥劑具相似之感受性。其中對異角釉小蜂與華釉小蜂影響最輕之藥劑為昆蟲生長調節劑 (insect growth regulator) 之賽滅淨，其次者為土壤微生物製劑 (avermectins) 之阿巴汀，再次者為有機磷劑 (organophosphates) 之白粉松，而海生類毒素 (nereistoxins) 之培丹、硫賜安及有機磷劑之三落松則對寄生蜂具巨大毒性。其原因筆者等推測或與賽滅淨與阿巴汀係同屬 translaminar 型之殺蟲劑，其藥劑成分滲透並貯存在葉肉組織內 (Weintraub, 2001)，而其他四種藥劑則屬傳統型速效性殺蟲劑，依藥劑之特性 (Liaw, 1990)，藥劑成分具移行或滲透性，對寄生蜂除具胃毒或神經毒外，培丹與三落松可能尚增加了接觸性毒害所致。

表六　異角釉小蜂與華釉小蜂成蟲經藥劑處理 24 小時後移至未施藥豆苗上之壽命、生殖力及致死寄主數 [1)]

Table 6. The longevity, fecundity and host-killing capability of insecticides treated *Hemiptarsenus varicornis* and *Neochrysocharis formosa* adults on untreated field bean seedling[1)]

Treatment	n	Longevity (d) Female	Longevity (d) Male	Fecundity (no. offspring wasps/female)	Female proportion	No. hosts killed/female Parasitized	Host feeding	Total	Parasitized/host feeding
				H. varicornis					
Abamectin	12	8.8 ± 1.8Ab	9.9 ± 1.7Ab	16 ± 9c	0.80 ± 0.06a	17 ± 9c	37 ± 18c	53 ± 26c	0.47 ± 0.04c
Cyromazine	9	17.7 ± 1.2Aa	15.2 ± 1.1Aa	95 ± 13b	0.69 ± 0.02b	104 ± 15b	93 ± 13b	197 ± 25b	1.11 ± 0.05a
CK	11	21.6 ± 1.6Aa	15.1 ± 1.2Ba	181 ± 22a	0.61 ± 0.02c	187 ± 19a	249 ± 21a	436 ± 38a	0.75 ± 0.05b
				N. formosa					
Abamectin	12	5.2 ± 0.3Bb	6.9 ± 0.7Aa	4 ± 4b	0.49 ± 0.03a	5 ± 5b	3 ± 3b	8 ± 8b	0.14 ± 0.14c
Cyromazine	7	21.4 ± 1.5Aa	7.0 ± 0.7Ba	215 ± 20a	0.44 ± 0.04a	243 ± 23a	114 ± 9a	357 ± 31a	2.14 ± 0.10a
CK	17	22.3 ± 1.2Aa	7.5 ± 0.7Ba	188 ± 18a	0.46 ± 0.04a	198 ± 17a	155 ± 17a	354 ± 32a	1.37 ± 0.14b

1) For every replicate, one pair of 3-day old wasp adults that had survived after 24 h insecticide treatment were placed in the acrylic cylinder (20 cm diameter × 25 cm high) under 25°C, 14L:10D, and 65-85% R.H. Untreated field bean seedling infested by 30-40 3rd-instars of *L. trifolii* were provided every day.

2) Means ($\bar{x}$ ± SEM) of longevity followed by the same uppercase letter denote that there are no significant differences between sexes (p < 0.05, t-test). Means ($\bar{x}$ ± SEM) within each row followed by the same lowercase letter are not significantly different (p < 0.05, LSD).

二、藥劑對寄生蜂各蟲期之影響

本試驗證實供試之六種藥劑對異角釉小蜂與華釉小蜂各蟲期之影響，雖因藥劑種類而異，但皆顯示藥劑對成蟲期之毒害大於未成熟期。其原因或與成蟲在搜尋寄主產卵與取食寄主 (host feeding) 時，其觸角、口器、足及產卵管直接接觸豆葉上之藥膜並取食已帶毒之寄主體液有關，因而受到藥劑之毒害較大；而未成熟期中之卵、老熟幼蟲及蛹卻因未曾與藥劑直接接觸，所以受到藥劑之毒害較成蟲輕。另藥劑對成蜂之毒害除直接影響 24 小時內之存活率、生殖力及子代雌性比外，亦對雌蜂 24 小時後之壽命、生育力及致死寄主數具部分亞致死影響 (sublethal effect)。

三、斑潛蠅幼蟲浸藥後時間對寄生蜂之影響

異角釉小蜂與華釉小蜂之產卵方式屬非共育寄生性 (idiobiont)，寄主幼蟲被產卵或取食後，各經 4～5.7 與 0 分鐘，即不再活動取食，各呈現深度麻痺與死亡 (Chien and Ku, 2001b, c)。因此斑潛蠅幼蟲浸藥後至接蜂之時間差距是否影響其獲毒量，進而對寄生蜂有不同之影響。本試驗結果發現，白粉松、阿巴汀及賽滅淨三種藥劑施藥後 30 分鐘與 1 日後接蜂兩處理間，對雌蟲之影響視蜂種與藥劑而定。就異角釉小蜂而言，三種藥劑對子代雌性比、阿巴汀對存活率及賽滅淨對生殖力等之毒害，施藥後 30 分鐘接蜂者較施藥後 1 日者各強 38.6～72.9、32.6 及 31.0%；但就華釉小蜂而言，阿巴汀對存活率與賽滅淨對生殖力之毒害，施藥後 1 日接蜂者反較施藥後 30 分鐘者各強 21.8 與 55.4%。至於其原因，目前尚不明瞭。

四、藥劑對兩種寄生蜂毒害之比較

異角釉小蜂與華釉小蜂各為非洲菊斑潛蠅幼蟲之體外與體內寄生蜂 (Chien and Ku, 2001b, c)。當比較同一種藥劑對兩種寄生蜂之

毒害程度時，發現藥劑種類與施藥蟲期均爲影響因子，不過概括而論，除三落松不論在寄生蜂未成熟期與成蟲期施用時，對兩種寄生蜂之毒害程度均相似外，其他五種藥劑對異角釉小蜂之毒害均大於華釉小蜂。如培丹與硫賜安於寄生蜂未成熟期施用時，異角釉小蜂所受之毒害大於華釉小蜂，但在成蟲期施用時，兩種寄生蜂所受毒害相似。白粉松與賽滅淨不論在寄生蜂未成熟期與成蟲期施用時，異角釉小蜂所受之毒害均大於華釉小蜂。阿巴汀在寄生蜂未成熟期施用時，兩種寄生蜂所受毒害雖亦相似，但在成蟲期施用時，雌蜂 24 小時內之存活率與子代雌性比，異角釉小蜂各大幅下降 52.0 與 74.5%，而華釉小蜂僅各降低 6.7 與 31.4%。至於培丹、硫賜安、白粉松及賽滅淨藥劑在寄生蜂卵期施用時，異角釉小蜂所受之毒害均大於華釉小蜂，其原因與該蜂寄生方式爲體外寄生、或與其蟲體對藥劑之感受性有關，尚待探討。

五、藥劑與寄生蜂對非洲菊斑潛蠅致死能力之比較

當第二日齡雌蜂數與非洲菊斑潛蠅第三齡幼蟲數之比例爲 20 隻：300 隻時，異角釉小蜂與華釉小蜂一日內致死寄主率各爲 88.9 與 69.2% (表五)，而六種供試藥劑單獨或分別與寄生蜂並用，對非洲菊斑潛蠅之致死率均各達 94.5～100% (Chien *et al*., 2007) 與 99.8～100% (表五)。顯示就致死非洲菊斑潛蠅方面，藥劑之效果確實優於寄生蜂，且藥劑與寄生蜂並用對非洲菊斑潛蠅之致死率，較異角釉小蜂與華釉小蜂單用時各增加 10.9～11.1 與 30.6～30.8%。因此證實非洲菊斑潛蠅田間族群密度若高至寄生蜂無法控制時，施用藥劑確可迅速降低該蠅之密度。但若考慮避免藥劑對寄生蜂之毒害、降低藥劑對非洲菊斑潛蠅與其寄生蜂族群穩定消長之干擾、減緩斑潛蠅抗藥性之產生、延長選擇性藥劑之使用壽命及降低防治成本等，在非洲菊斑潛蠅防治上必須慎選藥劑之種類與施用時機。日本靜岡縣於溫室內非洲菊上施用殺蟲劑與殺蟎劑時，發現當施用非選擇性藥劑，如醚菊酯 (ethofenprox)、納乃得 (methomyl)、百滅靈 (permethrin) 及普硫松 (prothiofos) 時，不僅寄生蜂因受藥劑影響數量銳減，導致非洲菊斑潛蠅猖獗，且寄生蜂對寄主之高寄生率需經 1 個月或 1 個月以上才能恢復；但施用選擇性藥劑，如布芬淨 (buprofezin)、大克蟎 (dicofol)、芬佈賜 (fenbutatin oxide)、芬普蟎 (fenpyroximate)、氟芬隆 (flufenoxuron) 及達蟎酮 (pyridaben) 等時，不僅寄生蜂受到保育，非洲菊斑潛蠅族群亦受到抑制 (Saito *et al*., 1996)。

六、斑潛蠅之綜合防治

斑潛蠅屬於侵入性害蟲，本地種寄生蜂在其防治上扮演重要角色 (Murphy and LaSalle, 1999)。廣效性藥劑不當施用時，不僅引發斑潛蠅抗藥性之產生，且對天敵造成殺傷力，致使斑潛蠅防治困難，因此在斑潛蠅防治上所採行之策略爲綜合防治而不僅限藥劑防治。賽滅淨與阿巴汀自 1980 年代中期迄今，已成功地用於觀賞園藝與蔬菜上斑潛蠅之防治 (Ferguson, 2004)。基於對本地種寄生蜂之保育 (Prijono *et al*., 2004; Bjorksten and Robinson, 2005) 與藥劑對光之敏感性 (Bull *et al*., 1984; Shipp *et al*., 2000)，以色列、印尼及澳洲等地在防治斑潛蠅時，認爲賽滅淨極適用於田間斑潛蠅之綜合防治；而阿巴汀卻因對寄生蜂之毒害較強與易受光分解之特性，施用方法不僅需注意藥劑濃度、界面劑之添加及在黎明或近日落時施用，適用範圍亦侷限在無

寄生蜂之溫室內，或藥劑施用後，寄生蜂族群密度能快速恢復之田間綜合防治系統。美國佛羅里達州與加里福尼亞州為減緩斑潛蠅抗藥性產生，於花卉與蔬菜上亦施行賽滅淨與阿巴汀之輪用 (FFVA, 1991; Ferguson, 2004)。本試驗結果顯示僅賽滅淨與異角釉小蜂與華釉小蜂之相容性佳，阿巴汀次之，其他四種藥劑則與寄生蜂不相容。同時非洲菊栽培植株每二至三年更新一次棲所穩定性強、僅收穫花的部分供做切花用之特性、及有效寄生蜂自然發生不需人為釋放等條件，致使非洲菊園內非洲菊斑潛蠅之防治應是以生物防治為主、藥劑防治為輔之綜合防治策略。因此祇要慎選賽滅淨防治非洲菊斑潛蠅，異角釉小蜂與華釉小蜂即可獲得較佳的保育，進而達成非洲菊斑潛蠅有效之綜合防治。

七、非洲菊園內病、蟲及蟎害之綜合防治

非洲菊栽培中除非洲菊斑潛蠅與白粉病為害外，尚有 15 種其他害蟲與害蟎之發生 (Wang and Lin, 1997)，為達非洲菊園內病、蟲及蟎害之經營管理，其防治方法必須做整體地規劃。綜合本試驗結果及非洲菊斑潛蠅之生活史與繁殖力 (Chien and Ku, 1996)、非洲菊斑潛蠅與其寄生蜂在非洲菊園之發生消長 (Chien and Ku, 1998)、異角釉小蜂與華釉小蜂對非洲菊斑潛蠅之防治潛能 (Chien and Ku, 2001a, b, c, 2002; Chien *et al.* 2004; Chien *et al.*, 2005a, b, c)、植物保護手冊 (Anonymous, 2004) 及非洲菊園內常用藥劑對非洲菊斑潛蠅之藥效探討 (Chien *et al.* 2007) 等資料，建議以下非洲菊園內病、蟲及蟎害之綜合防治策略。當非洲菊園內非洲菊斑潛蠅幼蟲因受其寄生蜂之抑制，呈現低密度穩定消長時，該蠅不需施藥防治，僅當該蠅幼蟲密度呈現突然暴升時，才需施用賽滅淨防治之。又當非洲菊園內有白粉病發生時建議施用白粉松，若有夜蛾類、毒蛾、蚜蟲、粉蝨、薊馬及蟎等發生時，則建議施用阿巴汀防治之。

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The Effect of Common Insecticides on Two Parasitoids (Hymenoptera: Eulophidae) of *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae)

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ABSTRACT

In Taiwan *Hemiptarsenus varicornis* (Girault) and *Neochrysocharis formosa* (Westwood) are important native parasitoids of *Liriomyza trifolii* (Burgess). Seedlings of field bean with either parasitoid or *L. trifolii* were used to study the effects of six insecticides (cartap, thiocyclam, triazophos, pyrazophos, abamectin, and cyromazine) on the different life stages of parasitoids by dipping method in the laboratory. The results showed that the susceptibility to insecticides were similar for both parasitoids. The most toxic insecticides were cartap, thiocyclam and triazophos, followed by pyrazophos, abamectin and cyromazine. The adult stage was more vulnerable to the tested insecticides than the immature stages. *N. formosa* was generally more tolerant to five of the insecticides tested than *H. varicornis*, but the susceptibility of both parasitoids to triazophos was similar. When comparing the use of only one of the parasitoids with the combination of both parasitoid and insecticide, the percentage of hosts killed by applying the parasitoid and the insecticide simultaneously increased 10.9～11.1 and 30.6～30.8% for *H. varicornis* and *N. formosa*, respectively. The results of this study suggest that cyromazine can conserve parasitoids and could be incorporated into *L. trifolii* control programs. Strategies for integrated management of disease, pests and mites on *Gerbera jamesonii* Bolues ex Hook. F. were also discussed.

Key words: *Liriomyza trifolii*, *Hemiptarsenus varicornis*, *Neochrysocharis formosa*, insecticides, stages

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